TMDL Development for the Queen Creek, King Creek, and Felgates Creek Watersheds

Public Meeting Number 2

York County Public Library

Yorktown, VA

May 2, 2007

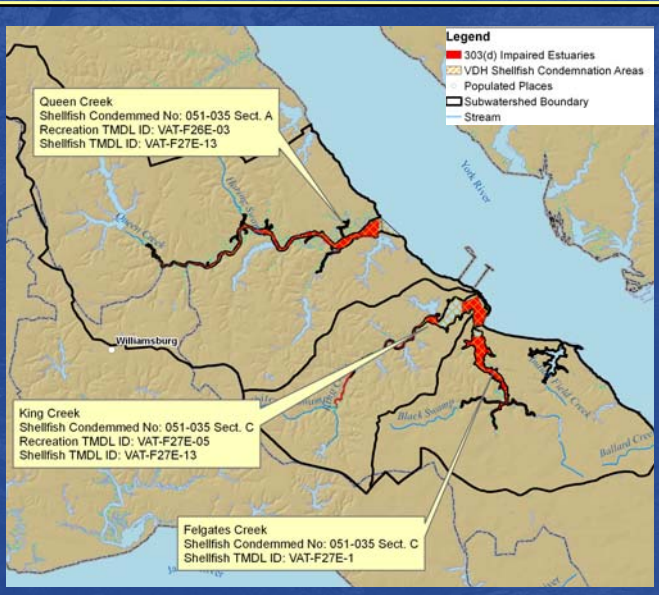
THE Louis Berger Group, INC.

Objective

Bacteria Impairment: Queen Creek, King Creek, and Felgates Creek

- Present and review the data and the steps used in the development of bacteria TMDLs
- Present draft bacteria TMDL allocations

Bacteria Impaired Segments



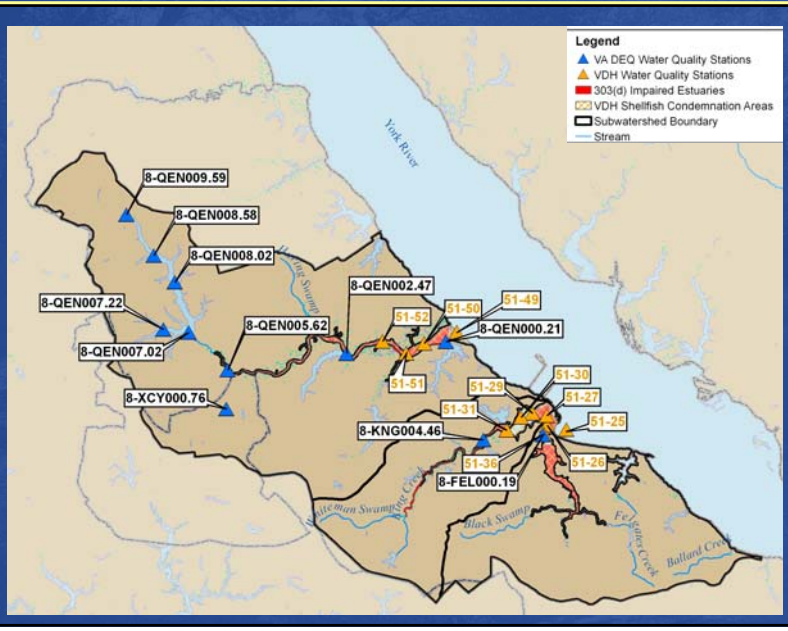
Bacteria Impairments

Shellfish Water Quality Standards

VADEQ specifies the following criteria (9 VAC 25-260-160) for shellfish propagating waters:

- Fecal coliform:
  - 14 cfu/100ml (geometric mean: applies to 2 or more samples obtained in 1 calendar month)
  - 49 cfu/100mL (90th percentile)

Water Quality Stations



Fecal Coliform Data Collected

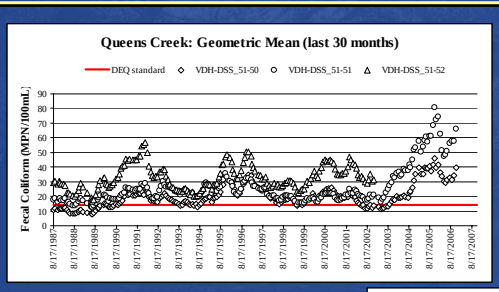
VA DEQ Stations

Stream	Station ID	Sample Date		No. of Samples
		First	Last	
Queen Creek	QEN002.47	1995	2006	93
	QEN005.62	1992	1995	31
King Creek	KNG004.46	1992	2006	122
Felgates Creek	FEL000.19	1992	2006	120

Virginia Department of Health (VDH) Stations

Stream	Station ID	Sample Date		No. of Samples
		First	Last	
Queen Creek	51 - 50	1985	2006	225
	51 - 51	1985	2006	225
	51 - 52	1985	2006	225
King Creek	51 - 29	1985	2006	225
	51 - 30	1985	2006	225
	51 - 31	1985	2006	225
Felgates Creek	51 - 26	1985	2006	225
	51 - 27	1985	2006	225
	51 - 36	1985	2006	225

Fecal Coliform Exceedances in Queen Creek

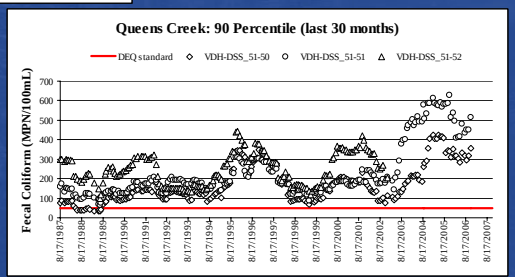


91% of the VDH Samples

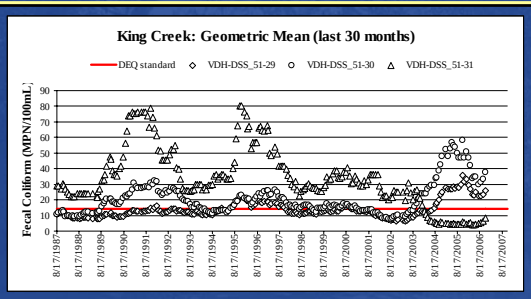
Exceed the Shellfish Bacteria Standard for Geometric Mean

98% of the VDH Samples

Exceed the Shellfish Bacteria Standard for 90th percentile



Fecal Coliform Exceedances in King Creek

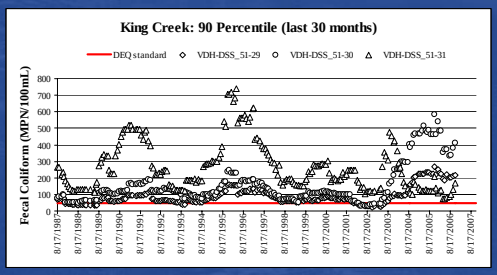


60% of the VDH Samples

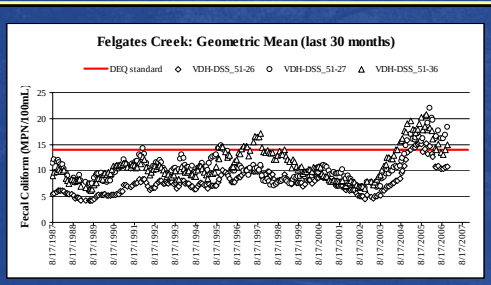
Exceed the Shellfish Bacteria Standard for Geometric Mean

90% of the VDH Samples

Exceed the Shellfish Bacteria Standard for 90th percentile



Fecal Coliform Exceedances in Felgates Creek

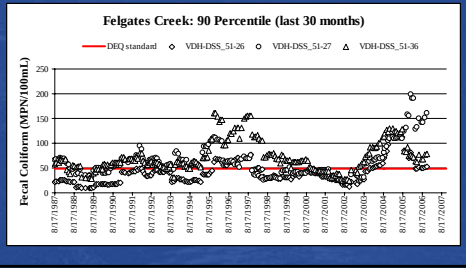


56% of the VDH Samples

Exceed the Shellfish Bacteria Standard for Geometric Mean

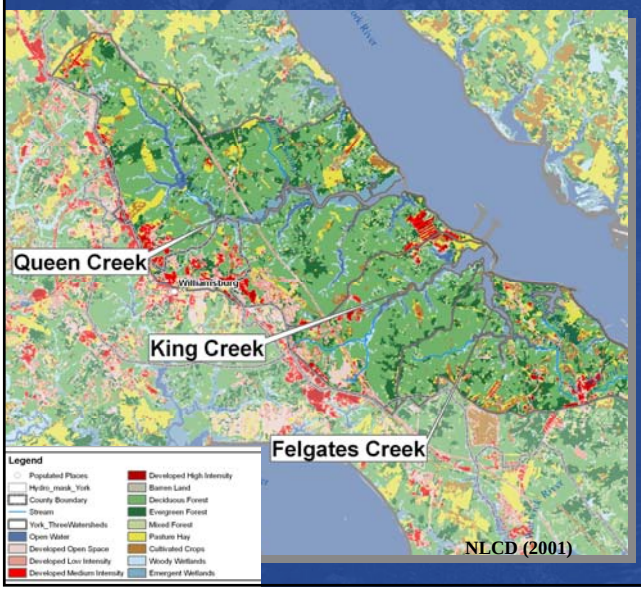
11% of the VDH Samples

Exceed the Shellfish Bacteria Standard for 90th percentile



Watershed Characterization

Watershed Land Use



NLCD (2001)

Queen Creek:
Total Acres: 16,116
62% Forest
13% Developed
12% Agriculture
12% Water/Wetland
1% Other

King Creek:
Total Acres: 4,840
67% Forest
14% Developed
8% Agriculture
10% Water/Wetland
1% Other

Felgates Creek:
Total Acres: 6,558
69% Forest
9% Developed
14% Agriculture
7% Water Wetland
1% Other

Bacteria Sources

Address bacteria loading from:

- Human Sources
- Livestock
- Wildlife
- Pets

Human Sources

Permitted Facilities:

Queens Creek: 1 VPDES permitted facility, 2 general permitted facilities

King Creek: 1 VPDES permitted facility, 2 general permitted facilities

Felgates Creek: 1 VPDES permitted facility

Means of Sewage Disposal:

Watershed	Population*	Number of Households*	Number of Households on Sewage Systems*	Number of Households on Septic Systems*	Number of Households on Failing Septic Systems **	Number of Households on Straight Pipes*
Queen Creek	9,431	3,471	2,537	925	111	10
King Creek	2,346	810	481	326	39	2
Felgates Creek	293	86	53	33	3	0

*US Census Data 2004 and 1990 housing distribution data for York County, Williamsburg, and James City County

** Based on an estimated failure rate of 12 %

Animal Estimates







Livestock Type*	Queen	King	Felgates
Cattle	19	7	7
Pigs	0	0	0
Chickens	10	4	5
Horses	21	6	15
Sheep	0	0	0

Wildlife Type*	Queen	King	Felgates
Ducks	1,045	242	288
Geese	778	181	215
Deer	1,004	315	309
Raccoons	871	271	203

*Information summarized by CCRM (Center for Costal Resource Management) 2004 and stakeholder comments

Name	Dogs	Cats
Queen Creek	1,885	2,058
King Creek	440	480
Felgates Creek	100*	100*

*Source: stakeholder comments

Pet inventories based on:

Cats: 0.598 per household

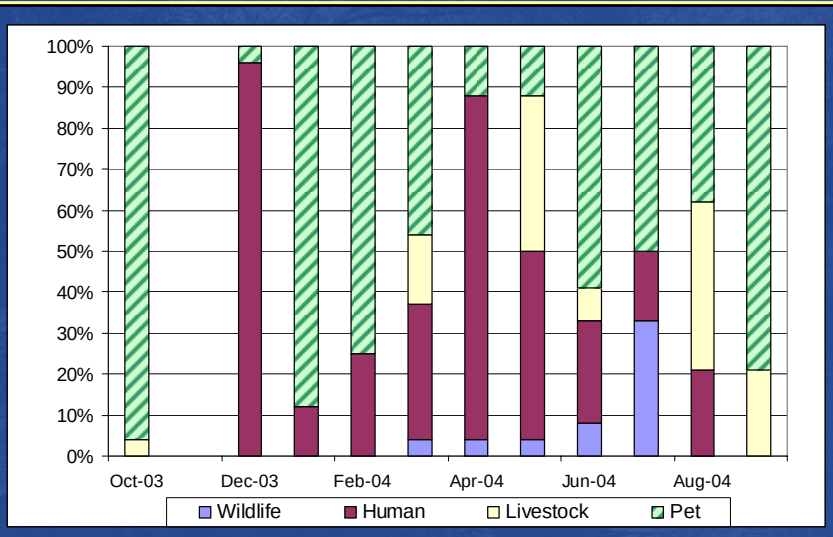
Dogs: 0.543 per household

American Veterinary Medical Association (AVMA) estimates (2005)

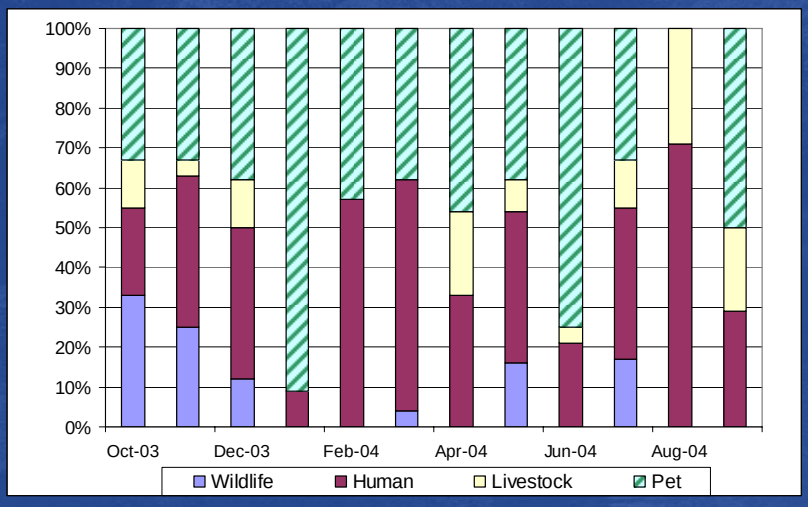
Bacteria Source Tracking (BST)

- BST was conducted monthly at 3 Stations by Virginia Department of Health (VDH)
  - 1 station on Queen Creek
  - 1 station on King Creek
  - 1 station on Felgates Creek
- A total of 12 sampling events at each station
- Results indicate that bacteria from human, livestock, wildlife, and pet sources is present in the watershed
- The BST distribution was used to develop the TMDL allocations

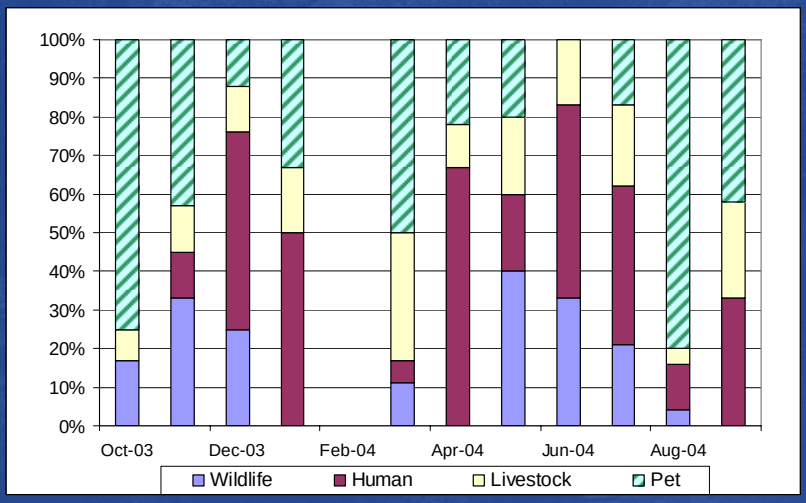
BST Source Distribution at Queen Creek Station 51-51



BST Source Distribution at King Creek Station 51-30



BST Source Distributions at Felgates Creek Station 51-36



Linking Sources to Water Quality

Use of the *Simplified Volumetric Tidal Model*

- Used for small watersheds
- Incorporates point and non-point sources
- EPA accepted
- Time independent
- Uses a mass balance approach over a tidal period (~12 hrs)
- Assumes a completely mixed system (no density, concentration, and volume variations)

Linking Sources to Water Quality

Input

- Maximum fecal concentration in the estuary
- Maximum fecal concentration at boundary at the mouth of the estuary
- Volumes of water at sea level , entering the bay, flowing out of the bay, and net freshwater
- Total daily fecal coliform die off rate

Model

Simplified Volumetric Tidal Model

Output

Total Fecal Load Capacity in the Condemned Estuary

- Existing Load
- Allocated Load

Source Loading

- **Non-point sources for bacteria loads include:**
  - Livestock
  - Wildlife
  - Human
  - Pets
- **Urban Runoff bacteria loads from permitted Municipal Separate Storm Sewer Systems (MS4s)**
  - Permits for Williamsburg City and York County

Existing Source Loading and Required Reductions

Creek	Station	Observed 90th percentile (MPN/100mL)	Current Load (Counts/day)	Allowable Load (Counts/day)	Required Reduction (%)
Queen	51-51	587	3.41E+13	2.54E+12	92.5
King	51-31	477	2.83E+12	2.38E+11	91.6
Felgates	51-36	130	1.86E+12	5.72E+11	69.2

[1] Maximum 90th percentile between 1998 and 2004

TMDL Expression

$$TMDL = \sum LA + \sum WLA + MOS$$

LA = Load allocation (nonpoint source contribution)
WLA = Waste load allocation (point source contribution)
MOS = Margin of safety

TMDL Allocation Strategy

- Load Allocation is based on BST (Bacteria Source Tracking) data
- Municipal Separate Storm Sewer Systems (MS4s): Waste Load Allocation is based on an area-weighted approach

MS4 Allocation Strategy

- The are-weighted area uses the following assumptions:
  - 100 percent of the livestock bacteria loads originates from agricultural lands (cropland and pasture)
  - 80 percent of the pet bacteria loads originate from urban areas; the remaining 20 percent comes from agricultural lands
  - 80 percent of wildlife bacteria loads originate from forested areas; 10 percent comes from agricultural lands, and 10 percent from urban areas
  - 50 percent of the human bacteria loads originates from the urban areas, the remaining 50 percent comes from agricultural lands
- And the land use distribution and proportion of each MS4 within the watershed

Queen Creek TMDL Allocations and Final TMDL

Waste Load Allocation for MS4

Permit Number	Municipality	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
VAR040027	Williamsburg	7.63E+12	4.43E+11	94%
VAR040028	York County	1.05E+13	5.27E+11	97%
Total		1.81E+13	9.69E+11	95%

Load Allocation

Source	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
Livestock	3.15E+12	8.45E+10	97%
Wildlife	1.33E+12	1.33E+12	0%
Human	5.63E+12	0.00E+00	100%
Pets	5.96E+12	1.60E+11	97%
Total	1.61E+13	1.57E+12	90%

Final TMDL

WLA (MS4s)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
9.69E+11	1.57E+12	IMPLICIT	2.54E+12

King Creek TMDL Allocations and Final TMDL

Waste Load Allocation for MS4

Permit Number	Municipality	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
VAR040028	York County	1.32E+12	4.37E+11	87%

Load Allocation

Source	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
Livestock	2.22E+11	1.42E+08	100%
Wildlife	2.06E+11	1.93E+11	6%
Human	5.79E+11	0.00E+00	100%
Pets	5.02E+11	3.21E+08	100%
Total	1.45E+12	1.94E+11	87%

Final TMDL

WLA (MS4)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
4.37E+10	1.94E+11	IMPLICIT	2.38E+11

Felgates Creek TMDL Allocations and Final TMDL

Waste Load Allocation for MS4

Permit Number	Municipality	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
VAR040028	York County	8.54E+10	3.16E+10	63%

Load Allocation

Source	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
Livestock	2.90E+11	8.14E+10	71.9%
Wildlife	2.79E+11	2.79E+11	0.0%
Human	5.62E+11	0.00E+00	100.0%
Pets	6.41E+11	1.80E+11	71.9%
Total	1.77E+12	5.40E+11	69.5%

Final TMDL

WLA (MS4)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
3.16E+10	5.40E+11	IMPLICIT	5.72E+11

Next Steps

- **Bacteria Impairment: Queen Creek, King Creek, and Felgates Creek**
  - Finalize TMDL Reports

Dissolved Oxygen Impairments

Objective

Dissolved Oxygen Impairment: Queen and King Creek

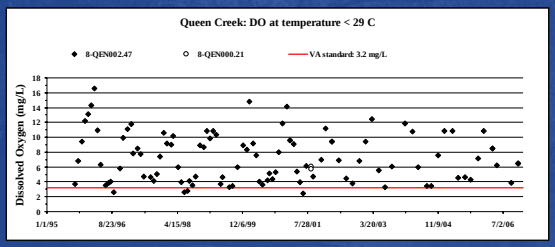
- Identify and assess the potential sources causing the low dissolved oxygen levels in the estuaries of Queen Creek and King Creek
- Show that the hydrology and water quality in the estuaries of Queen Creek and King Creek are dominated by the York River

Dissolved Oxygen Impairments and Water Quality Monitoring Stations

Applicable Water Quality Criteria for Dissolved Oxygen

Designated Use	Criteria Concentration/Duration	Temporal Application
Open water	30 day mean > 5.5 mg/L (tidal habitats with 0-0.5ppt salinity)	Year-round
	30 day mean > 5 mg/L (tidal habitats with > 0.5ppt salinity)	
	7 day mean > 4 mg/L	
	Instantaneous minimum > 3.2 mg/L at temperature < 29°C	
	Instantaneous minimum > 4.3 mg/L at temperature > 29°C	

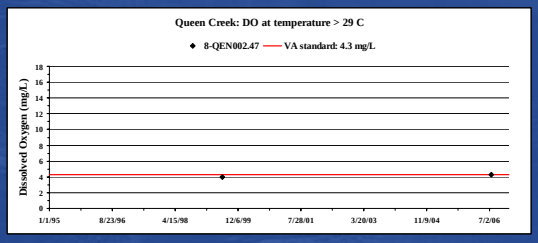
Dissolved Oxygen Exceedences in Queen Creek



4 out of 102 of the VA DEQ Samples

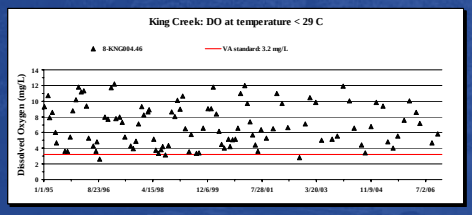
Exceed the instantaneous minimum DO Standard for temperature < 29°C

1 out of 2 of the VA DEQ Samples
Exceed the instantaneous minimum DO Standard for temperature > 29°C



The 30 day mean DO criterion and the 7 day mean DO criterion were not violated.

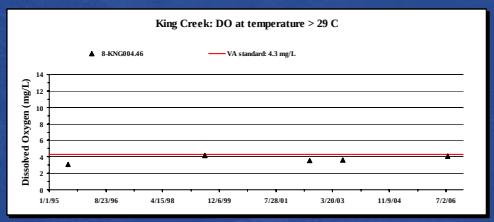
Dissolved Oxygen Exceedences in King Creek



Three out of 98 of the VA DEQ Samples

Exceed the instantaneous minimum DO Standard for temperature < 29°C

All of the VA DEQ Samples Exceed the instantaneous minimum DO Standard for temperature > 29°C



The 30 day mean DO criterion and the 7 day mean DO criterion were not violated.

Potential Causes of the Dissolved Oxygen Impairment

1. Nutrients and DO carried at flood tide by the York River to the estuaries

2. Large Salt Marshes in Queen Creek and King Creek watersheds

3. Non-point source nutrient loading from the Queen Creek and King Creek watersheds

Approaches to Estimate Nutrient Loads and Flows

- Queen Creek and King Creek Watersheds (land-based loads):
  - Generalized Watershed Loading Functions model GWLF (version 2.0).
  - GWLF model simulations were performed between 1996 and 2006

- York River (flood tide loads):
  - Simple mass balance model (simplified for small estuaries and jointly developed by EPA, VA DEQ, and other entities)
    - Calculates the volume of the flood tide and observed nutrient concentration in the York River

Estimated Water Volumes

- Volume of flood water from the York River was on average 14 times greater than the volume of incoming freshwater from Queen Creek
- Volume of flood water from the York River was on average 7 times greater than the volume of incoming freshwater from King Creek

The water balances in the estuaries of Queen Creek and King Creek are controlled by the York River

Estimated Nutrient Loads

Load Assessment	King Creek		Queen Creek	
	TN	TP	TN	TP
Watershed load (kg/tidal cycle)	5.12	0.41	14.18	0.98
York River load (kg/tidal cycle)	33.68	12.7	204.4	81.76
Fraction of load delivered by the watershed	13.20%	3.10%	6.50%	1.20%
Fraction of load delivered by the York River (flood tide)	86.8%	96.9%	93.5%	98.8%

The majority of the nutrient load to Queen Creek and King Creek Estuaries is delivered by the York River

Conclusions

Hydrology and water quality in the estuaries of Queen Creek and King Creek are dominated by the York River:

- **Volume of flood water (York River) was 14 times and 7 times greater than the volume of incoming freshwater in Queen Creek and King Creek**
- **Nutrient loads delivered by the York River accounted for the majority of the nutrient loads in Queen Creek and King Creek**

Unless York's River water quality is improved, the estuaries of Queen Creek and King Creek will continue to show exceedences of VADEQ dissolved oxygen standards

Local TMDL Contacts

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